Productivity and Plant Diversity in the Southeastern US

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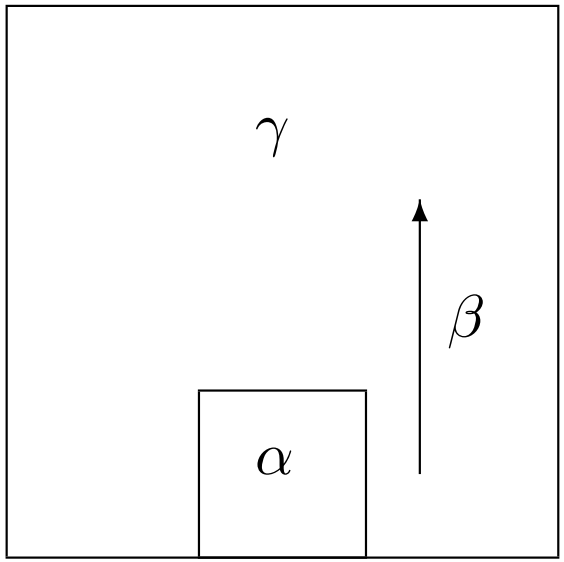
THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Outline

Types of Diversity
ala. Robert Whittaker

alpha local species richness
gamma regional species richness
beta change from alpha to gamma (now turnover)

- inter-dependent
- local & regional must be specified.



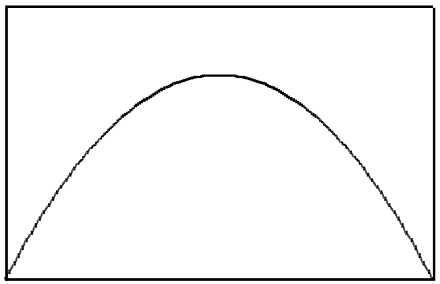
Productivity and Richness

Quadratic local. Positive linear regional.

- Many diversity-productivity experiments.
- General results (Mittelbach et al. 2001)

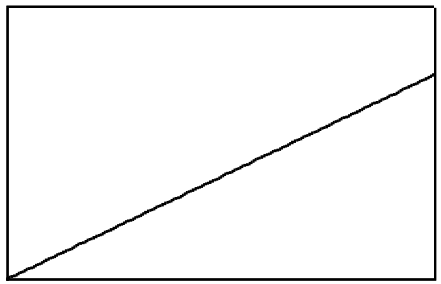
  alpha v. prod. varied but often quadratic (hump-backed)
  gamma v. prod. positive linear

alpha



productivity

gamma

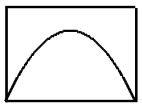


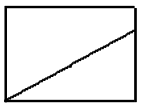
productivity

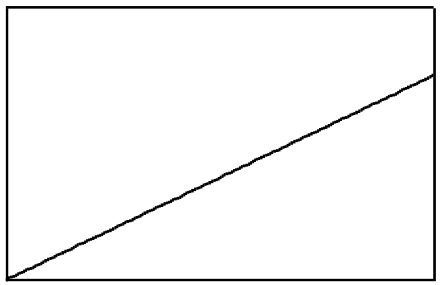
Connecting beta diversity to productivity

Derivations of Chase and Leibold (2004)

- Given a quadratic local and positive linear regional beta v. prod. positive linear
- Shown for:
  - Aquatic invertebrates in ponds (Chase and Leibold 2004)
  - Plants on serpentine soils in California (Harrison et al 2006)

alpha 
productivity

gamma 
productivity

beta 
productivity

Beta diversity - productivity hypotheses

History v. environment

- Species Pools
  1. Productive regions have more species
  2. Must be “packed” into local communities
- Environmental Heterogeneity
  1. Productive regions have greater heterogeneity
  2. More environments means more species and more turnover

- Environmental heterogeneity rejected in favor of species pools.

Questions

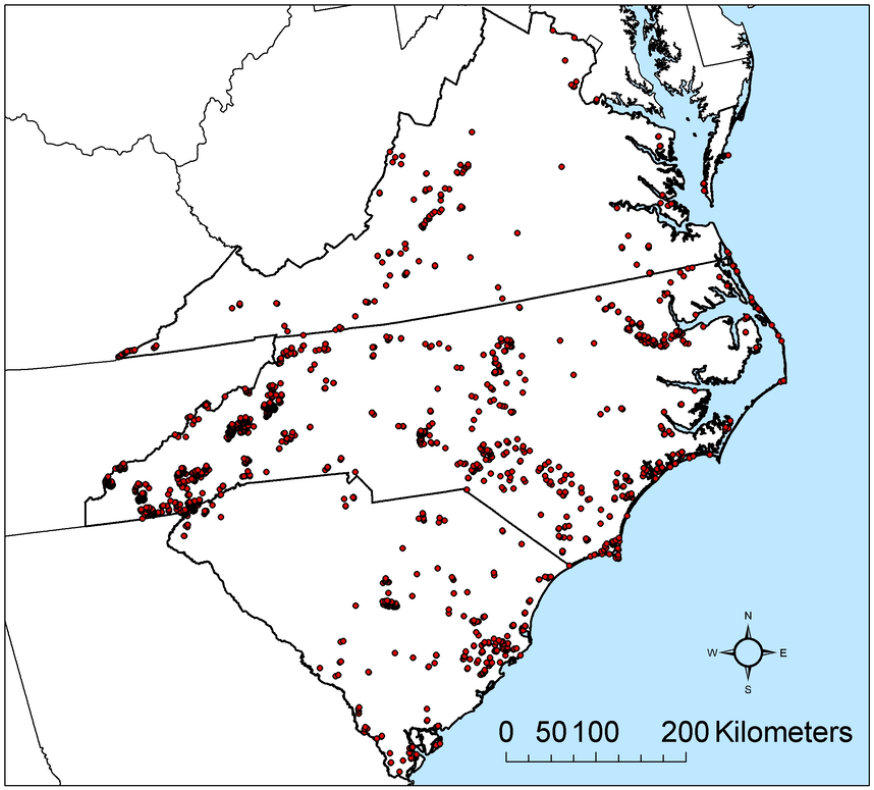
- Do alpha and gamma diversities exhibit hump-backed and positive linear relationships, respectively?
- Is beta diversity positively correlated with increasing with productivity?
- Is beta-diversity correlated with variance in productivity?

Improvements over previous studies

- Bigger dataset
- Greater extent

Plant Occurrence Data

- 2508, 1000m2 plots
- NC,SC,VA
- Sources:
  - Carolina Veg. Survey (Peet et al. 1996)
  - VA Natural Heritage Program (Lipford et al. 1987)

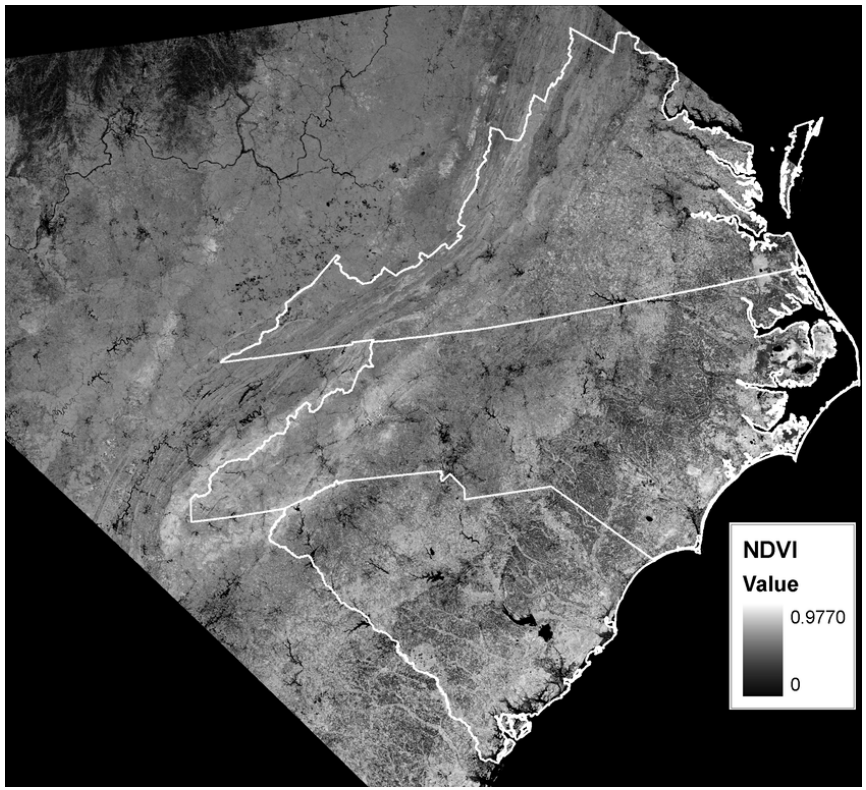


Productivity Data

NDVI Normalized Difference Vegetation Index

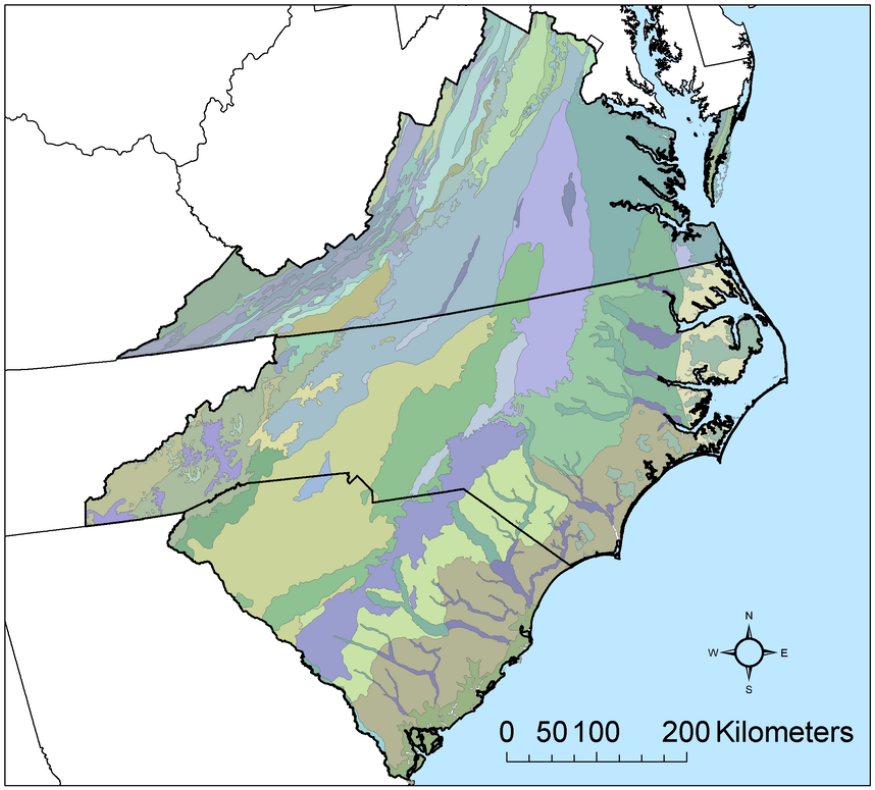
$$NDVI = \frac{NIR - RED}{NIR + RED}$$

- MODIS MOD13Q Vegetation Indices data
- Mean Jan. 1, 2001 to Dec. 31, 2007.
- 250m $\times$ 250m
- Used only values at plot locations



Regional Data

- EPA ecoregions level 4
- 42 ecoregions.
- Plots grouped
- Standardized for sample effort



Measuring alpha & gamma diversity-productivity

species richness v. NDVI

- Local (plot) and regional (ecoregion) scales
- Fit using Poisson GLM:

  Linear model $\log(S) = \beta_0 + \beta_1 P + \epsilon$

  Quadratic model $\log(S) = \beta_0 + \beta_1 P + \beta_2 P^2 + \epsilon$
- Discriminated using AIC
- Quantile regression for boundary behavior

Measuring beta diversity - productivity

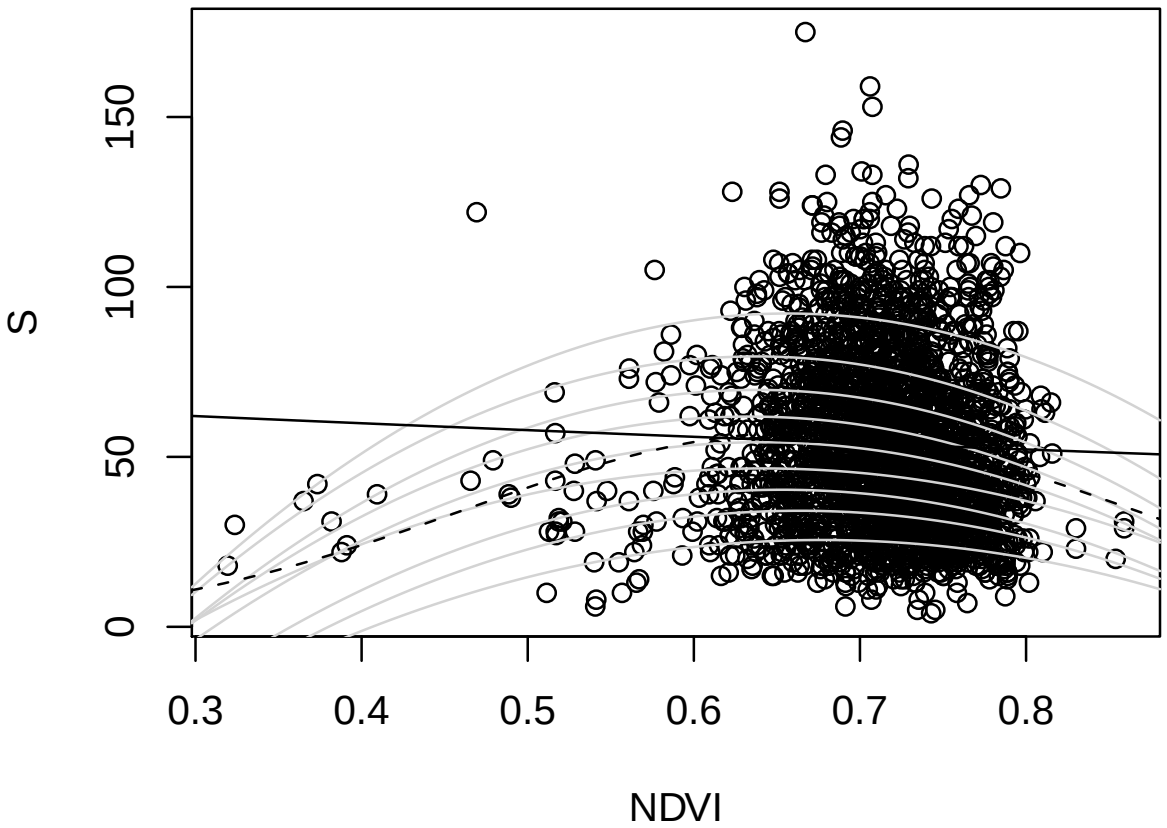
turnover v. NDVI

- Local turnover
  - Compositional distance between all plot pairs.
  - Jaccard's Distance: $J = 1 - \frac{A \cap B}{A \cup B}$
- Regional turnover
  - Mean compositional distance within ecoregions
- Productivity

local	Differences in NDVI
regional	Mean ecoregion NDVI
	Heterogeneity as variance in NDVI.

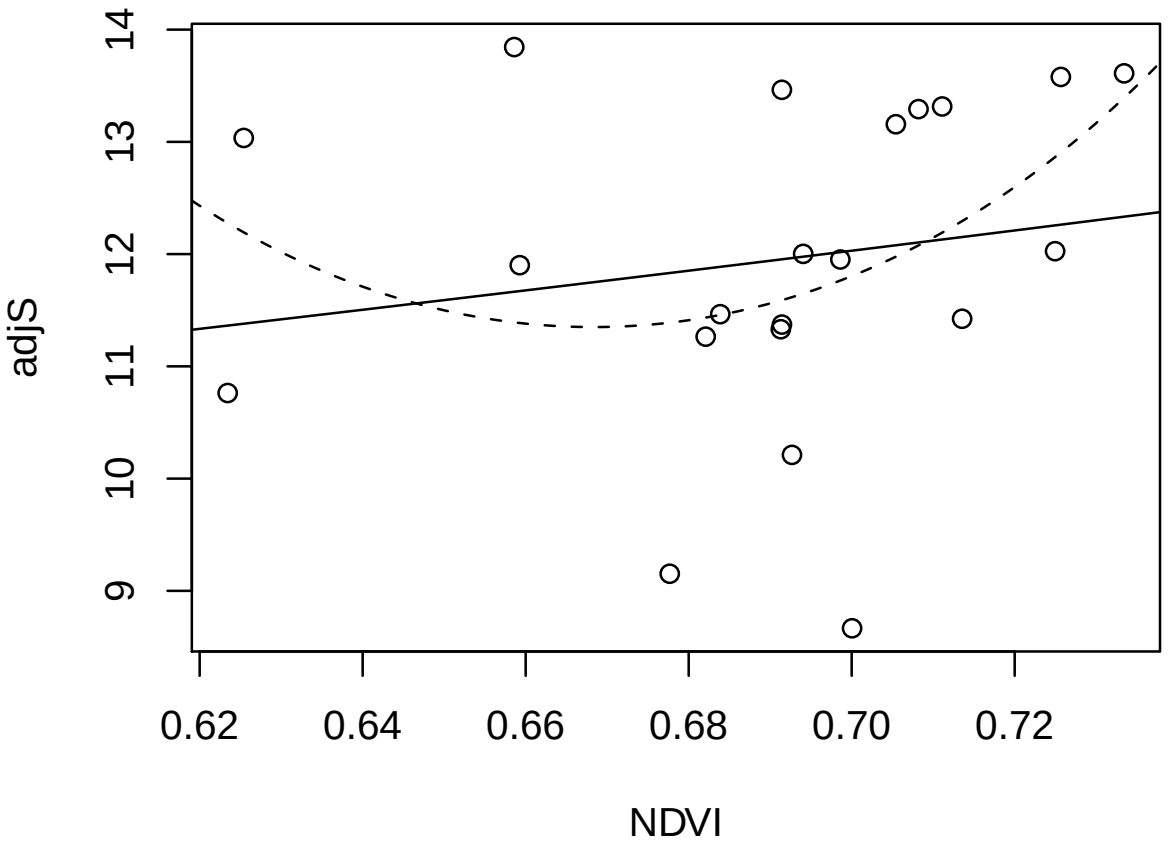
Alpha Diversity - Productivity is Quadratic

NDVI predicts local plot richness



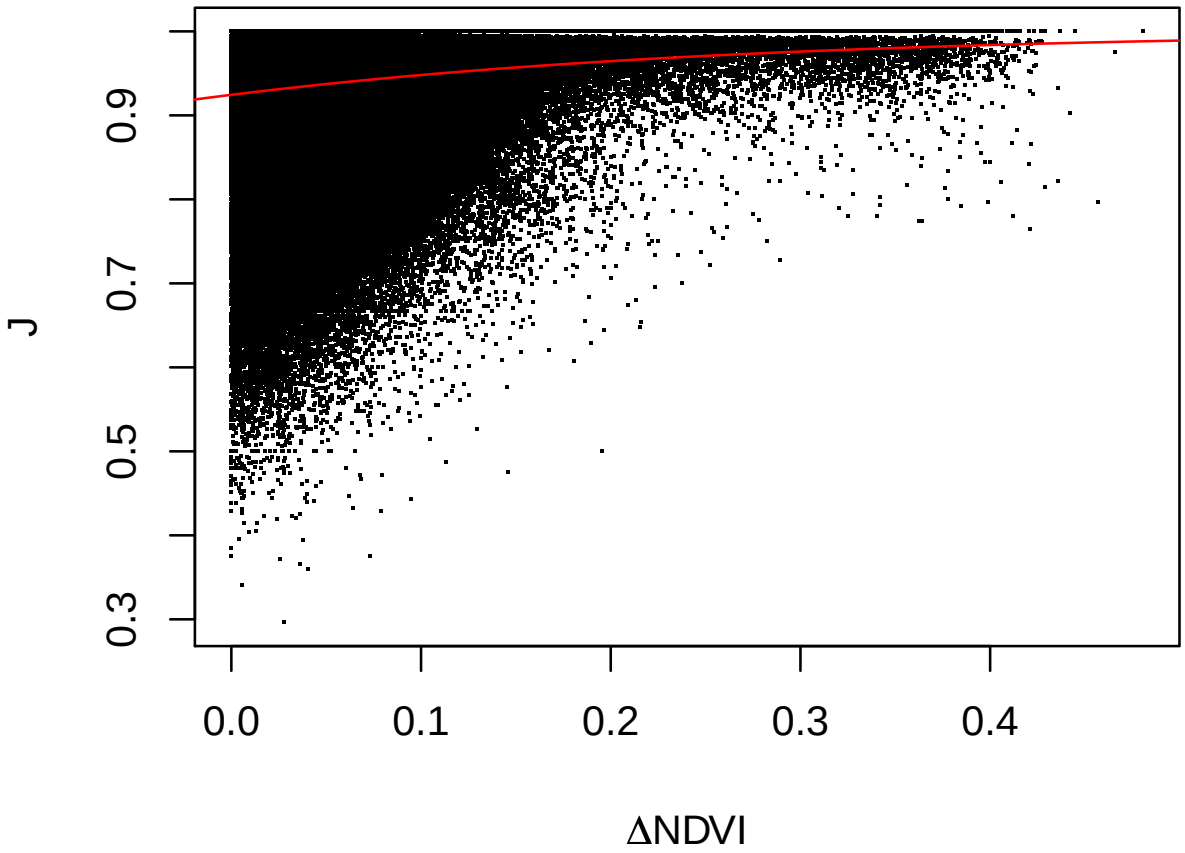
Gamma Diversity - Productivity Not Significant

NDVI does *not* predict ecoregion richness



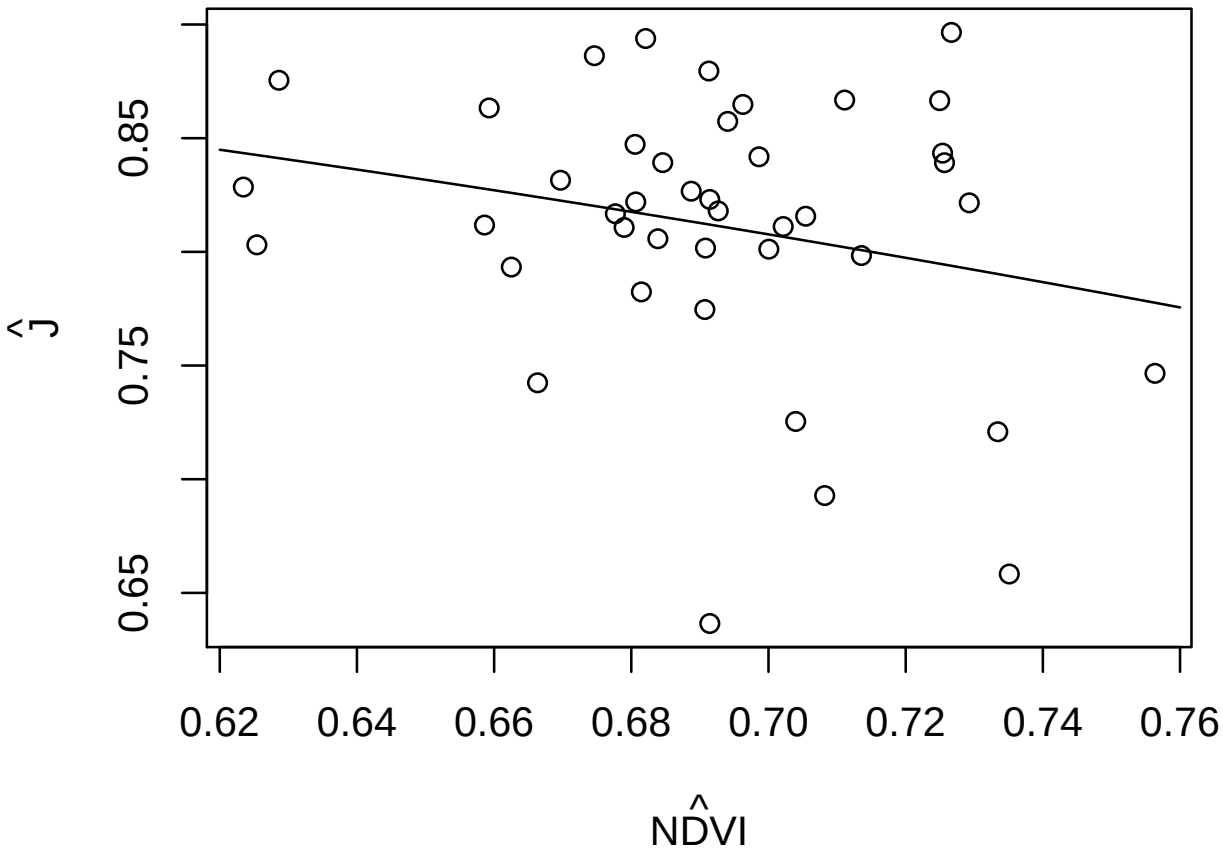
Local turnover - Productivity

positive



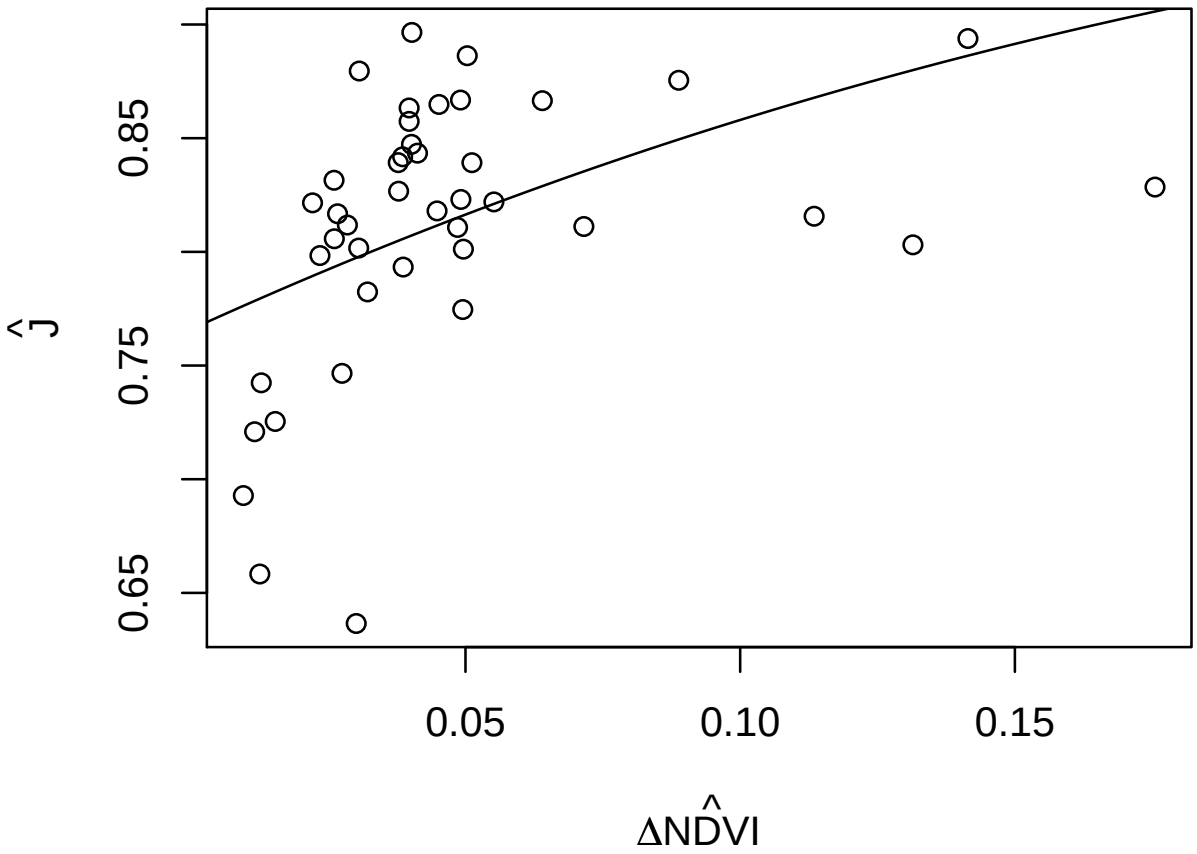
Regional Turnover - Productivity is not positive

Mean Compositional Distance possibly decreases with NDVI (P-Value=0.12)



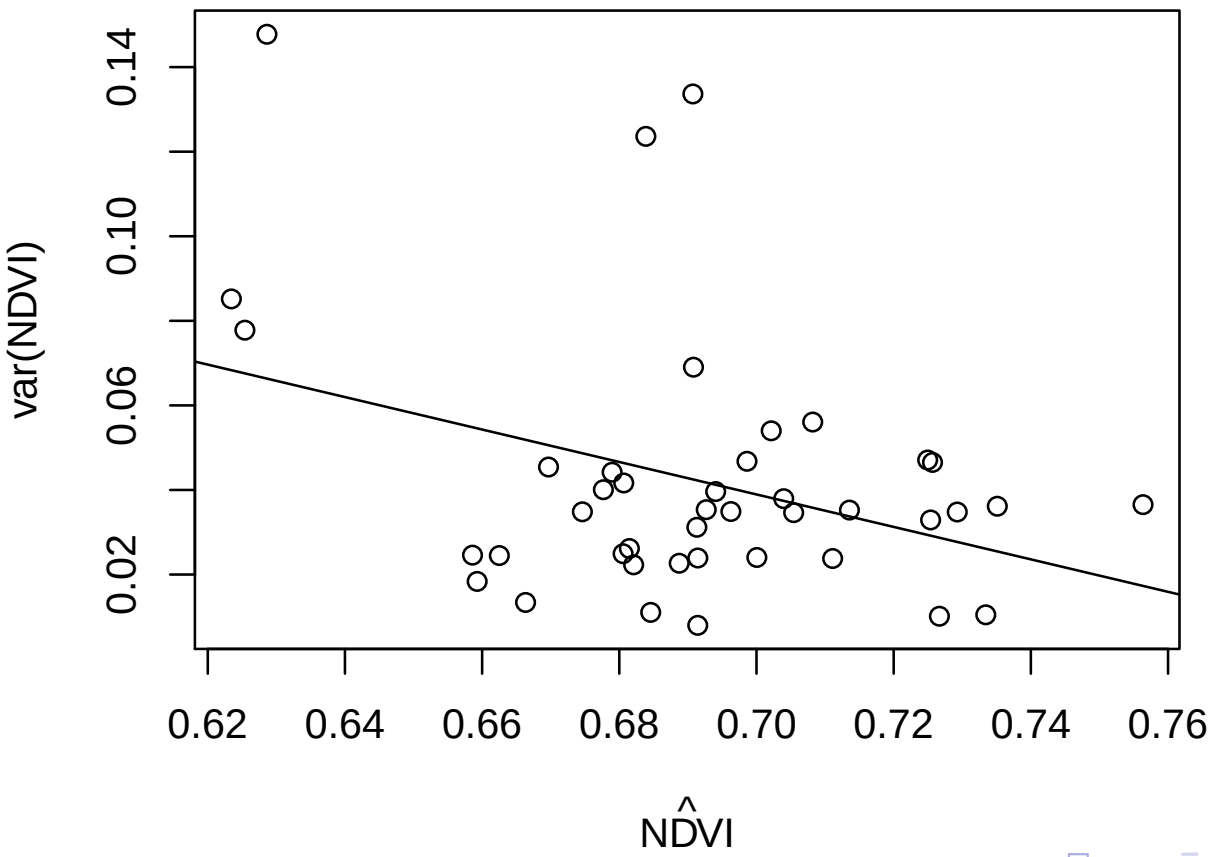
Regional Heterogeneity Predicts Turnover

Mean compositional distance increases with mean difference in NDVI



Variability in Productivity Greater for Low Productivity Ecosystems

Variance in NDVI decreases with mean NDVI



Answers

- Do alpha and gamma diversities exhibit hump-backed and positive linear relationships, respectively?
  - NDVI - alpha quadratic.
  - NDVI - gamma NS (possibly positive).
- Is beta diversity positively correlated with increasing with productivity?
  - local diff. NDVI - beta positive.
  - regional NDVI - beta NS (possibly negative).
- Is beta-diversity correlated with variance in productivity?
  - var NDVI - beta positive
  - var NDVI - mean NDVI negative

Summary

- Large scale analyses
- Beta div. - productivity relationships complex.
- Heterogeneity is back on the table as hypothesis

- Outlook
  - Scaling from 1000m2 plots to 62500m2 productivity.
  - Intermediate (county) scale relationships.
  - `bDivAndProd` R Package